Automatic frequency control for the Decca DC-19 weather radar

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AUTOMATIC FREQUENCY CONTROL FOR THE DECCA DC-19 WEATHER RADAR

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OTTAWA

MARCH 1959

ABSTRACT

A description is given of the automatic frequency control installed in the Decca DC-19 Weather Radar at RCAF Station, Penhold, Alberta. Minimum modification of existing circuits and radio-frequency waveguide configuration was required.

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I Modulator-transmitter unit of Decca DC-19 Radar modified for automatic frequency control

AUTOMATIC FREQUENCY CONTROL FOR THE DECCA DC-19 WEATHER RADAR

- R.S. McClean -

INTRODUCTION

A Decca DC-19 Weather Radar was used during the past two summers at RCAF Station, Penhold, Alberta, to record the growth, location, and progress of thunderstorms in connection with the Alberta Hail Studies program. The radar was not equipped with automatic frequency control but had sufficient frequency stability to be quite suitable for standard weather observation. However, it has been found that by measuring the height of cloud tops, the operator can determine which clouds are high enough to produce hail. Such measurements are made by noting the tilt angle of the antenna at which minimum detectable signal is observed, and, knowing the slant range, the height can be calculated. It can be seen that any variation in receiver sensitivity due to frequency drift of the local oscillator will result in incorrect height measurement. Manual tuning of the klystron by different operators can result in differences in height readings of 4000 to 6000 feet at ranges of 50 miles or more.

Further, a logarithmic intermediate-frequency amplifier will be installed in the DC-19 Radar. It is to be used for reflectivity measurements during the 1959 hail season. To avoid serious errors in these measurements, frequency stability between magnetron and local oscillator is most important.

The automatic frequency control to be described here is designed to maintain the local oscillator at a frequency 30 mc/s below that of the magnetron. The AFC chassis is a modified form of that described by Mott [1]. The installation required minimum modification of the existing circuits and waveguide configuration. The method of switching from automatic frequency control to manual tuning is also described.

DESCRIPTION OF EQUIPMENT

A diagram of the modifications made in the existing RF waveguide appears in Fig. 1. The shaded portion shows the original waveguide. The modified waveguide configuration and the location of the AFC chassis are shown in Plate I. Space limitations necessitated mounting the AFC chassis above the modulator-transmitter chassis.

Waveguide Configuration

The magnetron frequency is sampled through an orifice designed to attenuate the power some 40 to 50 db. The power is attenuated up to 10 db further by an adjustable flap attenuator. This sample is combined with a sample of local oscillator signal at the AFC mixer and the resulting difference-frequency signal is fed to the input of the AFC receiver.

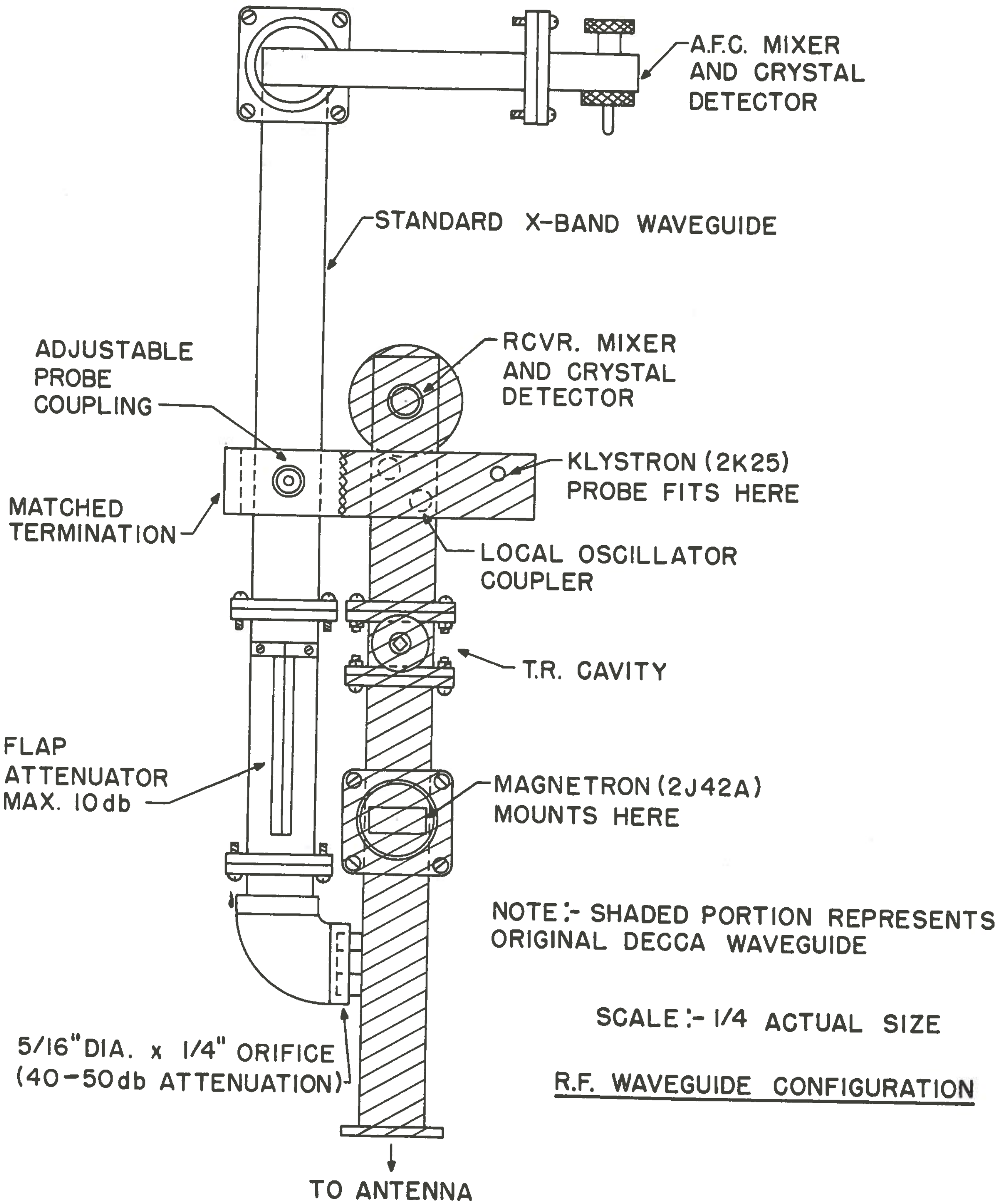


FIG. 1 MODIFICATION OF RADIO-FREQUENCY WAVEGUIDE

AFC Chassis

Fig. 2 is the circuit diagram of the AFC chassis. The input stage, having a bandwidth of 20 mc/s, is followed by a 7 mc/s "triple". The discriminator is of the Foster-Seeley type, the primary coil being included in the center frequency stage of the triple. This is tuned to the frequency of the radar receiver, viz., 30.25 mc/s. The crossover point of the discriminator is tunable with capacitor C_2 and can be monitored at TP_1. The stage comprising V_5 is a video amplifier. The phantastron circuit, comprising V_7, is arranged to sweep from -420 volts to -475 volts, the latter voltage being adjustable down to -525 volts by means of P_1. V_{6A} is a search-stopper diode. V_{6B}, the low-end clamp tube, prevents the unit from locking on a lower frequency mode of the local oscillator by determining the more positive limit of the phantastron sweep voltage. The rate of sweep of the phantastron, determined by the time constant of R_1, C_3, is approximately two sweeps per second. Test Point TP_2 provides a convenient means of monitoring the AFC voltage.

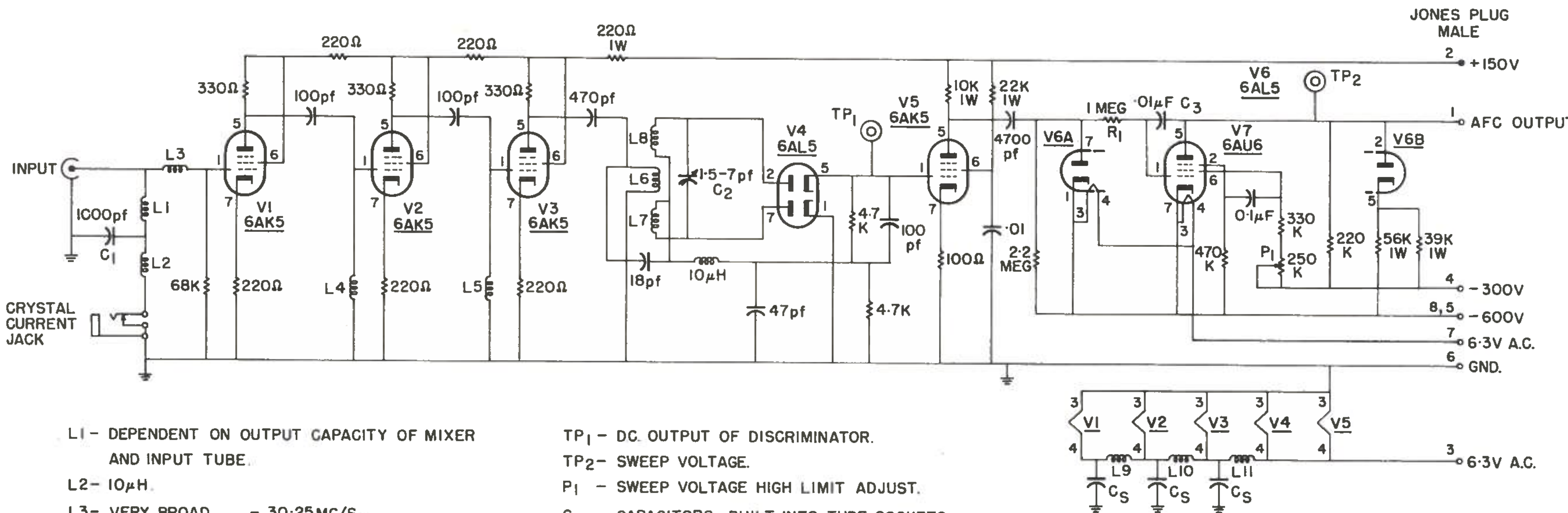
MODIFICATIONS TO THE CONTROL UNIT AND MODULATOR-TRANSMITTER CIRCUITRY (see Fig. 3)

The AFC chassis requires a -600 volt supply for operation of the phantastron circuit. This voltage is provided by a small -300 volt power supply, wired in series with the existing -300 volt supply, which replaces the -190 volt supply originally used. Manual tuning voltage, adjustable from -420 volts to -520 volts, is provided by the bleeder R_1, R_2, P_1. Selector switch SW_1 permits switching to manual tuning or AFC at the control point.

The following modifications have been made to the Modulator-Transmitter unit. Relay RL_1 and two type-OB2 tubes, V_{1M} and V_{2M}, are installed to permit switching from manual tuning to automatic frequency control. This circuit is described in a later paragraph of this report. A telephone jack is installed to read receiver crystal current at the antenna location, and a crystal current meter which can be plugged into either this jack or the AFC crystal current jack is provided. The +250 volt supply already in the unit provides +150 volts for the AFC chassis through a suitable dropping resistor. Ample current reserve is available in filament transformer T_{23} to provide filament voltage for the first six tubes, and through a 1:1 isolating transformer, to V_6 and V_7 of the AFC chassis.

SWITCHING CIRCUIT: MANUAL TUNING - AFC

Only one slip ring (and a common -300 volt lead) is available to provide manual



L1 - DEPENDENT ON OUTPUT CAPACITY OF MIXER AND INPUT TUBE.

L2 - 10μH.

L3 - VERY BROAD - 30·25MC/S.

L4 - LOW OF TRIPLE - 26·75MC/S.

L5 - HIGH OF TRIPLE - 33·75MC/S.

L6 - CENTRE FREQUENCY - 30·25MC/S

L7 - LOW OF DISCRIMINATOR.

L8 - HIGH OF DISCRIMINATOR.

L9, L10, L11 - FILAMENT FILTER CHOKES. 24 TURNS # 22 FORMEX ON 1/4" DIA. FORMER.

TP_1 - DC. OUTPUT OF DISCRIMINATOR.

TP_2 - SWEEP VOLTAGE.

P_1 - SWEEP VOLTAGE HIGH LIMIT ADJUST.

C_S - CAPACITORS BUILT INTO TUBE SOCKETS ON PINS 3,6 AND 7 FOR FILAMENT, SCREEN AND CATHODE BYPASS — 1000pf EACH.

ALL RESISTORS ARE 1/2 WATT UNLESS OTHERWISE SHOWN.

FIG. 2 CIRCUIT DIAGRAM OF AFC CHASSIS

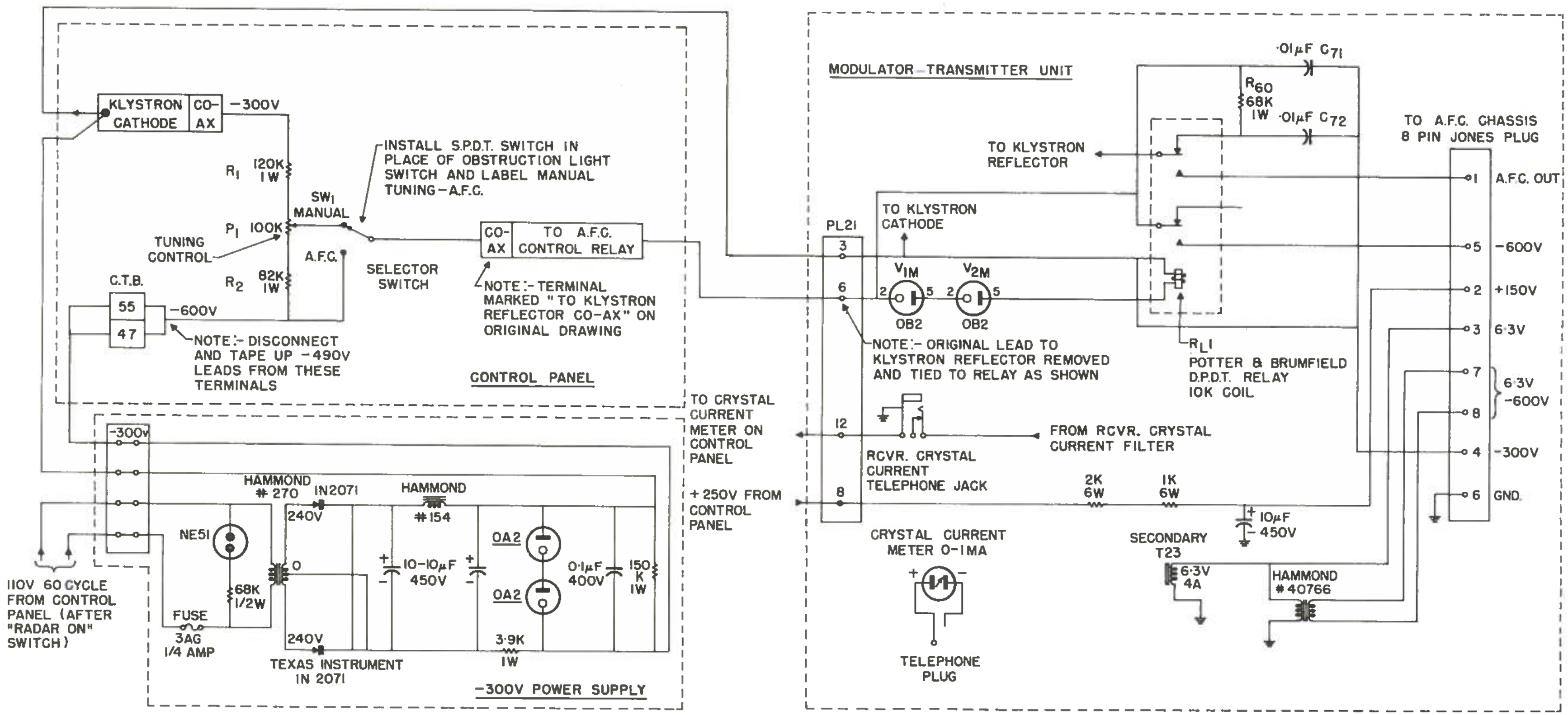


FIG. 3 MODIFICATIONS TO CONTROL UNIT AND MODULATOR-TRANSMITTER CIRCUITRY

tuning voltage to the klystron or -600 volts to the AFC chassis, at which time the klystron reflector is connected to the AFC voltage. A DPDT relay, RL_1, in the Modulator-Transmitter unit, is used for the switching. Manual tuning voltage which does not exceed -520 volts is fed through the slip ring when selector switch SW_1 is in the manual tuning position. This voltage is insufficient to cause tubes V_{1M} and V_{2M} to strike; no current flows through the coil of RL_1 and the relay remains unactuated. Thus the manual tuning voltage is fed to the klystron reflector and the -600 volt lead to the AFC chassis is disconnected. With the selector switch in the AFC position, the -600 volts fed to the relay is sufficient to cause V_{1M} and V_{2M} to strike and to cause current to flow and actuate the relay. In this position, -600 volts is supplied to the AFC chassis and the AFC voltage is fed to the klystron reflector.

Acknowledgements

The author is indebted to Mr. W.L. Haney who provided technical advice and made time available for this work and to Mr. R.I. Mott for assistance in developing and testing the circuitry.

Reference

1. Mott, R.I. A high-speed time base for PPI radar display. NRC Report ERB-289, August 1952

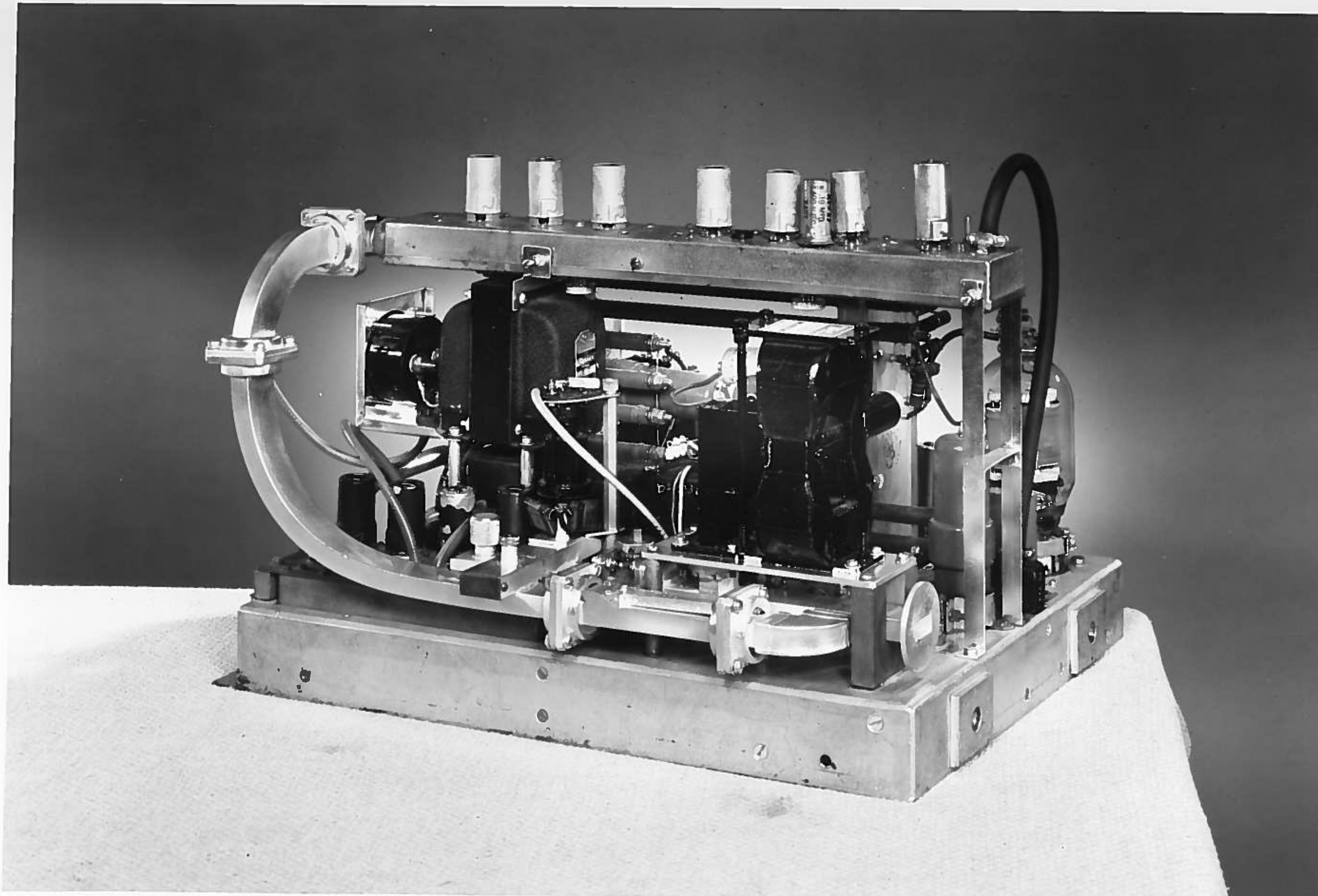


PLATE I — MODULATOR-TRANSMITTER UNIT OF DECCA DC-19 RADAR
MODIFIED FOR AUTOMATIC FREQUENCY CONTROL